THE SILVER LINING OF RUST BELT MANUFACTURING DECLINE: KILLING OFF POLLUTION EXTERNALITIES

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Abstract

This paper exploits a unique merger of air quality and county manufacturing data to quantify manufacturing's pollution externality by industry. By linking pollution to local production, I estimate cross-sectional pollution production regressions. Rust Belt cities that were endowed with the largest concentrations of the dirtiest industries experience reduced pollution externalities. I estimate that Gary, Indiana and Pittsburgh, Pennsylvania experienced substantial pollution declines as local primary metals activity declined in the 1970s and 1980s.

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I. Introduction

Between 1967 and 1987, the Rust Belt experienced a 62% decline in employment in primary metals plants (SIC 33).[1] Table One shows that this industry’s national employment contracted from 1.28 million jobs in 1967 to .701 million in 1987. As this industry’s employment shrank by 45.3%, the Rust Belt’s share of employment in this industry fell from 57.2% to 39.5%.[2] Rust Belt cities such as Pittsburgh, Pennsylvania and Gary, Indiana have experienced significant changes to their economies. Time trends in sectoral employment shares indicate that Rust Belt manufacturing is shrinking and the service sector is expanding. Table Two reports trends in the share of manufacturing and service employment for the nation, the Rust Belt, the non-Rust Belt and Los Angeles and Pittsburgh in 1970, 1980, and 1989. Outside the Rust Belt, manufacturing grew by 22.1% between 1970 and 1989. Inside the Rust Belt, manufacturing declined by 23.6% over this time period and Pittsburgh’s manufacturing employment fell by 53.4%.

[1] I define the Rust Belt as; Illinois, Indiana, Michigan, New Jersey, New York, Ohio, Pennsylvania, West Virginia.

[2] Barnett and Crandall (1986) present an excellent account of this industry’s dynamics.

Labor studies have quantified the costs of manufacturing decline (Jacobson, Lalonde and Sullivan 1993, Neal 1995).[3] A benefit of reduced manufacturing is improved environmental quality. Between 1981 and 1986, Pittsburgh's mean particulate level decreased by 27.1% while the nation experienced a 14.9% decrease. If manufacturing's local environmental externality was large and people value a clean environment, then Rust Belt cities such as Pittsburgh or Gary may experience sharp improvements in quality of life.

This paper exploits a unique geographical merger of county ambient air quality data to manufacturing plant level micro data to quantify manufacturing's pollution externality. By linking pollution to local production, I estimate cross-sectional pollution production regressions to study each industry's contribution to local pollution. For cities whose employment is concentrated in these industries, there would be large environmental gains from reduced manufacturing activity. I predict for manufacturing cities such as Pittsburgh how its air quality has evolved because of heavy manufacturing decline. The dollar value of this environmental quality improvements is calculated by multiplying my estimates of the pollution impact

[3]Neal (1995) reports a 31% wage premium in the primary metals industry over retail sales. Jacobson, Lalonde and Sullivan's (1993) findings suggest that some displaced manufacturing workers suffer wage losses of $10 per hour as they transfer to the service sector. Integrated steel company shareholders experienced sharp losses between 1976 and 1985 with the average New York Stock Exchange listed steel company suffering a 50% loss in market value (Barnett and Crandall 1986 Table 1.6).

of manufacturing by per unit valuation estimates from the hedonic and epidemiology literatures. For two indicators of pollution, ambient particulate levels and toxic releases, I find evidence that there is a local environmental “silver lining” only for counties whose economies were specialized in heavy manufacturing such as primary metals.

This paper’s estimates of manufacturing’s pollution externality are useful for calculating the net value added of manufacturing activity. A “green accounting” exercise should recognize that if increased manufacturing activity raises pollution and pollution lowers health levels then the depreciation of health capital should be taken into account when judging the benefits of an economy specialized in manufacturing. My estimates are relevant for considering the potential environmental gains for Eastern European nations that have experienced reduced heavy manufacturing levels. These estimates are useful for considering whether cities such as Pittsburgh have experienced a significant increase in their local quality of life such that they can attract footloose service sector employment.[6] By documenting the negative correlation between local air

[6]The November 11, 1996 issue of Fortune reports “Once upon a time, Pittsburgh was all soot, steel and Steelers. But the smokestacks have given way to glass towers as the city has gone from working class to classy ... As a home to eight FORTUNE 500 companies it still has plenty of economic strength. It’s just that in the new Pittsburgh, only 3% of the work force earns a living producing primary metals.” (Page 140). Fortune magazine ranks Pittsburgh as the #9 “Best City” to live in. Whether steel’s decline is the sole cause of Pittsburgh perceived improvements is an open question and would require a model of migrant and service firm locational choice.

quality levels and local manufacturing activity, this paper links industry dynamics to city amenity levels. With the exception of Gyourko and Tracy (1989,1991), the spatial compensating differentials literature has implicitly assumed that local public goods are exogenously supplied such as climate (Blomquist, Berger and Hoehn 1988).[7] This paper does not attempt to compare the private benefits to manufacturing workers and capitalists from high polluting manufacturing activity versus the social environmental benefits of reduced activity. By estimating county level pollution production functions, I test political economy theories of what county level factors affect manufacturing pollution levels (Deily and Gray 1991, Grossman and Krueger 1995).

This paper is organized as follows. Section Two presents the empirical framework for estimating the dollar value of a Rust Belt city's pollution externality. Section Three discusses several data sets used in the analysis. Section Four presents my findings and Section Five concludes.

II. An Empirical Framework for Estimating Manufacturing's Pollution Externality

[7]Intuitively, local amenities such as quality public schools and low crime rates should be positively correlated with industry cycles because a booming economy provides a larger tax base which can be used to finance greater service levels.

Since air quality is a local public good, the environmental benefits of a reduction in polluting activity is the product of the number of individuals affected multiplied by their individual willingness to pay per unit of pollution reduction multiplied by the change in pollution with respect to industrial activity. For example in a county with a population of 80, if each person is willing to pay $4 per unit reduction of pollution and reduced manufacturing causes a 5 unit reduction in pollution, then the county's total environmental benefits from reduced activity is $1600.

This paper's empirical focus is to quantify the slope of the pollution production function to estimate how pollution changes with respect to economic activity levels. In the pollution production regressions, a data point is a county/year. For example, I fit Cook county in Illinois (Chicago) ambient air pollution levels in 1982 as a function of economic activity within the county. Defining SIC(h) as total economic activity in a SIC two digit industry named "h" (such as primary metals). Equation (1) presents a model to explain pollution levels in county j at time t.

$$pollution_{jt} = \sum_h \mathrm{B}_{ht} * SIC(h)_{jt} + \psi * X_{jt} + \epsilon_{jt} \qquad (1)$$

Estimates of equation (1) yield which industries create the largest externalities and an estimate of the size of the externalities. The # estimates indicate each industry's marginal pollution impact. Each industry's pollution impact can be estimated because counties differ in their manufacturing composition. Some are endowed with high concentrations of dirty industry while others are not.

In estimating equation (1) using OLS, I assume that E(, | SIC(h), X) =0 which assumes that a county's current manufacturing level is not a function of its current pollution level. Recent research has found some evidence that growth in local manufacturing levels is a function of environmental regulation (Gray 1996).[8] A location's environmental regulation is a function of lagged air quality. It is important to note that almost all Rust Belt manufacturing plants were built before the Clean Air Act of 1970 and thus they are regulated under a less stringent regulatory code than new sources (Portney 1990 p39).[9] Thus, a

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[8]In Kahn (1997), I report that controlling for non-manufacturing employment growth, county level manufacturing growth from 1982-1988 was 14% lower in counties that were not in attainment with the Clean Air Act's particulate standard in 1977 relative to counties that did not monitor air quality. Henderson (1996) reports similar evidence that chemical plants were less likely to locate in ozone non-attainment areas.

[9]In addition, Deily and Gray (1991) document that local governments ease regulatory constraints when they appear to threaten local employment prospects. Barnett and Crandall (1986) do not mention environmental regulation as a reason for the decline of integrated steel. They stress high labor costs, increased competition and lower demand.

Rust Belt county’s level of manufacturing activity is unlikely to be a function of current pollution.[10] A second assumption implicit in estimating equation (1) is that all manufacturing within a given two digit SIC code is fungible (i.e has the same impact on county air pollution).[11] There would be a larger pollution reduction if less regulated older vintage plants shut down.

This paper uses total value shipped, not total employment, as a proxy for a county/industry’s activity in a given year. A county/industry’s yearly total value shipped is highly correlated with total employment in that county in that industry. While estimating equation (1) using county/industry employment is a direct method for linking jobs to pollution levels, it does not control for the fact that industries are changing their capital to labor ratios over time toward reduced labor and higher average product of labor.[12] For example if the average product of labor doubles from 1972 to 1982, then a county/industry which had 50

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[10]If there was great concern about manufacturing’s endogeneity, I could instrument using lagged county manufacturing.

[11]Deily and Gray (1996) jointly model a steel plant’s environmental emissions compliance decision, the plant’s closing decision and an enforcement decision made by regulators. They find that greater enforcement leads to greater compliance while more compliant firms face less enforcement.

[12]In earlier versions of this paper, I directly regressed air quality on a county’s manufacturing employment mix. These estimates are available on request. While this identifies pollution per worker at a point in time, I cannot use this estimate to predict earlier pollution levels using historical data on employment within the county if the average product of labor has changed over time.

workers in 1972 and 50 in 1982 would be producing much more output in 1982 than in 1972. Given that one of my goals is to interpolate how manufacturing decline has affected specific city’s air quality levels, ignoring changes in the average product of labor would lead me to overestimate past industrial levels and overestimate previous pollution levels. I correct for this by using total value shipped (output) as the economic indicator.

To link employment to pollution, I estimate equation (1) using total value shipped as the proxy for economic activity. For each industry in year t this yields an estimate of the pollution per unit of economic activity parameter: #. To relate total value shipped by two digit SIC to total employment in a given year, I estimate equation (2) which yields the average value product of labor in each year for each two digit SIC industry.

$$\phi_{ht} = \left(\sum_j SIC(h)_{jt}\right) / \left(\sum_j Emp(h)_{jt}\right) \qquad \textbf{(2)}$$

Substituting the estimates from equation (2) into equation (1) and setting all other variables to zero yields equation (3);

$$pollution_{jt} = \sum_h \mathrm{B}_{ht} * \phi_{ht} * (emp(h))_{jt} \qquad (3)$$

Equation (3) relates a county's employment in each industry h at a point in time to its air quality level. I use this equation to calculate for Pittsburgh, Gary, and Los Angeles how changes in employment levels from 1972-1987 have affected local air quality. Equation (3) is used to interpolate the counter-factual of what a city's yearly pollution would have been had industrial activity remained at its earlier levels. As a polluting industry such as SIC 33 declines over time, this index shows the "silver lining". If B, pollution per unit of economic activity, is low then there will not be a large "silver lining" measured in units of pollution.

In the specifications presented below, the pollution production regression presented in equation (1) is augmented along several important dimensions. Two counties with similar industrial activity levels might have different levels of pollution because regulation is differentially enforced, or counties differ with respect to climate, or face different levels of cross-boundary externalities. To control for these factors, the X matrix includes proxies for county level politics, income, state fixed effects, and cross-county pollution externalities. Holding a county’s industrial composition and activity level constant, richer counties may have greater demand for clean air. Thus, I include proxies for county real income and income squared.[13] I also include manufacturing’s share of total county employment to study whether manufacturing is less regulated where it is more heavily concentrated as a key local employer (Deily and Gray 1991).[14] In addition, I include a county’s average manufacturing firm’s size as an indicator of industrial composition.

It is possible that regulation’s enforcement is partially a function of environmental taste among the populace. To control for environmental ideology variables, I include the percentage of the population who voted for the Democrat candidate for President in the previous election.[15] To control for cross-boundary externalities, I match each county to its adjacent counties to create proxies for total neighboring manufacturing activity. To

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[13]Note that in the specification, I am controlling for industrial composition so income is not proxying for high levels of dirty activity. If the environment is a normal good, then richer counties should have lower pollution levels because regulation is more likely to be enforced (Selden and Song (1995)).

[14] Deily and Gray (1991) find that plants that had a higher probability of closing faced less stringent regulation and that plants in high unemployment areas face less regulatory actions. Implicitly, local regulators may be engaging in the cost/benefit exercise of trading off jobs for environmental quality.

[15]Kahn and Matsusaka (1997) report some evidence that a California county’s share of registered Democrats helps explains a county’s propensity to vote in favor of environmental regulation even after controlling for other county covariates such as per-capita income and industrial structure.

control for climate and geography, I include state fixed effects. State fixed effects are also likely to control for regulatory differences across states. In addition to including state fixed effects in some specifications, I explore what is the impact of a dummy variable indicating whether a county was assigned to particulate non-attainment status in 1977. New plants in counties not in attainment of Clean Air Act standards face more stringent regulation while Pre-Clean Air Act vintage plants are "grandfathered" and face less stringent regulation.[16]

Combining estimates of equation (1) and equation (2), I calculate equation (3) which yields estimates of the quantity of a city's reduced pollution caused by reduced manufacturing. To translate this physical measure of improvement in air quality into dollar value benefits one needs an estimate of the marginal value per unit. Both hedonic studies (Blomquist et. al. 1988, Smith and Hwang 1995) and epidemiological studies Portney and Mullahy 1990, Ranson and Pope 1995) consistently indicate that people value lower particulate levels. Since air quality is a local public good, these external benefits are conveyed to all who live in the county.

It is important to note that because the pollution measure is ambient air quality, I can use estimates from the

[16]Henderson (1996) reports that counties that are assigned to non-attainment status for ozone smog experience a 7% reduction in pollution relative to their pre-regulation levels.

environmental valuation literature to calculate “silver lining” estimates of the benefits of the reduction in the externality. This is relevant because an alternative to using ambient air quality by county would be to use firm level emissions estimates as a dependent variable in equation (1) and to run a micro plant level regression. While estimated micro emissions data seems attractive, ambient environmental measures dominate because individuals ultimately care about ambient air quality not emissions. In addition, the validity of estimated emissions has been questioned because the “engineering” emissions factors are not reflective of in use emissions. Plants have private information about the deterioration of pollution abatement capital and their investment in variable environmental protection. Thus, reported emissions factors are likely to underestimate actual emissions.[17]

III. Pollution Regression Data

As outlined in Section II, the first step in calculating the “silver lining” of declining manufacturing is to estimate the magnitude of each industry’s manufacturing’s externality. To

[17] With respect to in-fleet vehicle emissions, the EPA’s Mobile 5.0 data indicates that actual vehicle emissions per mile are much higher than the new car standard a given make is supposed to achieve. This is evidence that ideal emissions per unit of economic activity are not reflective of actual emissions.

estimate equation (1), I use micro plant level data on manufacturing activity from the Census Bureau's Longitudinal Research Database (LRD) which is a panel data set of economic variables collected from manufacturing establishments in the Census of Manufacturers and Annual Survey of Manufacturers programs. The LRD file contains establishment level identifying information on the factors of production and the products produced (LRD Technical Documentation Manual 1992). For each plant in the Unites States, the data file identifies its state and county. This data set includes information on the plant's total value shipped, total employment in 1967, 1972, 1977, 1982 and 1987, the plant's SIC code and its state and county location.[18] For each plant in a given two digit SIC category, I add up total value shipped by county and deflate this using the Bartelsman and Gray (1996) price deflator for value of shipments. This manipulation yields for each county/industry in each year, its real total value shipped. I scale this by county land area to create the density of total value shipped for each county/industry.

Other key independent variables in equation (1) are county income, manufacturing share of a county employment, average firm size, and county politics. Average manufacturing plant size is created using the LRD data. The other variables are from the City

[18]Dunne, Roberts, and Samuelson (1988,1989) study the dynamics of industry employment using the LRD.

and County data book. To create, the cross-boundary externality variables I used the Contiguous County File (ICPSR tape #09835) which gives each county's fips code and the adjacent fips codes. Merging LRD data by county for the neighboring counties allows me to create any cross-boundary manufacturing proxy.

This paper focuses on pollutants associated with Rust Belt manufacturing activity.[19] In particular, I study ambient particulates and sulfur dioxide which are two of the six ambient pollutants regulated under the Clean Air Act and total pounds of toxic emissions. The Environmental Protection Agency is the source of my air pollution data. The EPA chooses monitoring locations to identify which areas are not in attainment of the Clean Air Act standards so that it can impose more stringent regulation to bring these areas into compliance. EPA monitoring intensity varies across states.[20] The EPA's Aerometric Information Retrieval System (AIRS) data base allows me to construct each county's weighted yearly mean ambient pollution

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[19]Ozone is an important pollutant that is not analyzed in this paper. Henderson (1996) provides an excellent analysis of industry's contribution to local ozone levels and ozone regulation's effectiveness. Los Angeles and Denver have the worst ozone problems in the country. Industries that contribute to ozone include: plastics (SIC 282,307), Industrial organic chemicals (SIC 286), Steel (SIC 331) and Petroleum Refining (291). In addition to chemical manufacturing, vehicles are a major source of hydrocarbon emissions (a precursor of ozone). In Kahn (1996), I document that vehicle emissions are sharply declining with respect to model year.

[20]In California in 1981, there was one particulate monitoring station for every 161,000 people while in Ohio there was one particulate monitoring station for every 32,000 people. There is at least one particulate monitoring station in 35% of all counties. In 1981, Los Angeles county had 10 stations while Allegheny county (Pittsburgh) and Lake county (Gary, Indiana) had 20 and 26 stations respectively.

levels for particulates and sulfur dioxide. Unfortunately, the EPA did not produce a data network to create a national comparable data set in the 1970s. Crandall (1983) reports evidence of a downward trend in particulates in the 1970s (p. 18). My particulate data set includes data on 1072 counties in 1982 and 970 in 1987. Average employment and manufacturing activity in counties that the EPA monitored ambient particulates was roughly ten times employment in counties that the EPA did not monitor. This is evidence that the EPA is concentrating its efforts in more populated area featuring higher levels of economic activity. Sulfur dioxide is used as another air quality indicator. Coal fired electric utility plants supply 80% of sulfur dioxide emissions.[21] To proxy for electric utility coal use, I use data from the State Energy Data Book on each state's electric utility consumption of coal. It is interesting to note that my ambient sulfur dioxide data indicates that concentration levels in Gary, Indiana (Lake county) fell by over 50% between 1970 and 1975 and have been roughly constant from 1975 to 1985 even as industry shrunk sharply in this county.

While it is difficult to proxy for particulate regulation, one tangible proxy exists. I use the 1979 Federal Registar 40 CFR

[21]Coal fired electric utilities have been a major supplier of sulfur dioxide emissions an particulate emissions. There has been a sharp decline in utility emissions between 1975 and 1987 as they installed scrubbing technology. Freeman and Jaggi (1991) provide detailed case studies of how over 100 major electric utility plants reduced their emissions. The State Energy Consumption Estimates (1989) is the source of my data on state coal consumption by electric utilities.

part 81 to assign all counties into two groups; those in attainment and those not in attainment with the Clean Air Act's particulate standard.[22] Counties not in attainment face stricter regulation to bring them into compliance. Non-attainment counties face more stringent regulation of new and existing polluting sources (see Portney 1981). Nationwide, 366 counties were assigned to non-attainment status. I find that 45% of all non-attainment counties were in the Rust Belt and a random Rust Belt county has a 26.3% chance of being non-attainment but a non-Rust Belt county had only a 7.4% probability of being classified as non-attainment in 1977. Since 1987, the EPA has focused its regulatory efforts on a subset of smaller particulates called PM10. In 1987, 97 counties were assigned to be non-attainment areas. These counties are located mostly in the west.

Ambient air pollution is not the only environmental margin affected by manufacturing. Manufacturing contributes to water pollution and to bloating landfills through waste disposal. SIC 33 is the third largest producer (of 20 industries) of total pounds of releases, second in largest producer of underground injections, and is the largest producer of releases to land. Of the largest 50 producers of toxic releases, fifteen are primary metals plants. This suggests that declines in this sector have

[22]The Primary Standard required that an area not have a single monitoring station whose yearly geometric mean exceeded 75 micrograms per cubic meter.

large environmental benefits beyond improved ambient air quality. To address these margins, I use a third environmental data set. Using the EPA (1996) cd-rom on the Toxic Release Inventory (TRI), I extract the 1988 data. The TRI contains specific toxic chemical release information from manufacturing facilities throughout the United States. This inventory was established under the Emergency Planning and Community Right to Know Act of 1986 which Congress passed to promote planning for chemical emergencies and to provide information to the public about the presence and release of toxic and hazardous chemicals in their communities. The TRI indicates each facilities' emissions of 343 chemicals. The problem with TRI data is that its units are pounds of emissions.[23] This is not ambient environmental quality and thus there are no environmental benefit estimates to translate pollution reductions into dollar benefits. For example, the five major chemicals released by SIC 33 are Toluene, Methanol, Methyl Ethyl Ketone, Xylene and Ammonia. While the TRI data is collected at the plant level there are no identifiers to merge it at the plant level to the LRD. Instead, I use the county identifiers and calculate for each county/industry in 1988, total toxic releases per dollar of value shipped. This

[23]A second problem with TRI data is that it is self reported. I have found no evidence on what are the penalties for falsely declaring emissions or how a given plant's emissions could be "audited" to learn its true emissions.

is my dependent variable and represents the pollution per unit of economic activity. Table Three presents the summary statistics.

V. Findings

Which Industries Create Pollution?

Air pollution (as measured by particulates) is lower in counties with less manufacturing activity and especially if there is less SIC 33 activity. In 1982, mean particulate levels for counties with below national median steel production levels was 49.1. This is significantly smaller than the mean for counties in the top 10% of steel activity which was 59.4.[24] This difference represents roughly a standard deviation of particulates.[25] Aggregate manufacturing levels have a smaller but positive effect on particulates. Average particulates for counties in the lowest 10% of the manufacturing activity distribution was 50.0 while it was 56.0 for counties in the top 10% of the manufacturing distribution.

To further explore each industry's pollution contribution, each column of Table Four presents a separate estimate of

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[24]Crandall (1993) provides an excellent industry overview sketching how import competition, the rise of southern minimills, and union driven high labor costs decreased Rust Belt plant competitiveness. Barnett and Crandall (1986) sketch the differences in integrated steel production (the majority of Rust Belt activity) with minimill production. For more on steel's production process see Russell and Vaughan (1976).

[25]Roughly 25% of the counties in the 1982 sample report no SIC 33 activity.

equation (1).[26] My goal is to identify which industries have a statistically significant impact on county particulate levels and to quantify how large is this effect. In results that are available on request, I have included all 20 two digit SIC industrial activity variables as independent regressors. Unfortunately, there is a high degree of multicollinearity between these economic proxies. In addition to this multivariate regression, I have also estimated 20 separate county particulate regression models to isolate a given industry's particulate externality controlling only for total employment in the county. I found positive and statistically significant industry impacts for ten industries that include: SIC 23 (apparel and other textiles), SIC 27 (printing and publishing), SIC 28 (chemicals), SIC 29 (rubber and petroleum), SIC 30 (rubber and plastics), SIC 32 (stone, clay, glass), SIC 33 (primary metals), SIC 34 (fabricated metals), SIC 35 (industrial machinery) and SIC 37 (transportation equipment). The individual industry elasticities for this group of ten ranged from .007% (SIC 28) to .034% (SIC 32). The pollution elasticity for primary metals was .022%. Clearly, these are small estimates and suggest that only those areas where there has been a substantial decline in economic activity will experience improved particulate levels.

[26] All of the particulate and sulfur dioxide regressions are weighted by the number of monitoring stations within a county in a given year.

Given the high correlation across county/industry variables, the SIC(h) in equation (1), I have simplified the specification to include SIC 29, 30,32, 33,34 and have aggregated up the remaining categories into an “all other manufacturing” category.

Specification (1) presents a particulates levels regression using the 1982 cross-section for 1,072 counties where particulates were monitored. Each of the independent variables is measured as industry’s total value shipped per square mile of county land area measured in millions of 1987 dollars. The key finding in specification (1) is that the primary metals industry has a positive and statistically significant (at the 1% level) impact on particulates. Its coefficient of 1.85 indicates that an extra standard deviation of primary metals activity raises pollution by 1.4 micrograms per cubic meter.[27] As I discuss below, this coefficient’s size indicates that if 10,000 jobs in SIC 33 in Allegheny, Pennsylvania (Pittsburgh) vanished then air quality would improve by 3 units (1/4 of a standard deviation in 1982). While this effect would not appear to be large, it is the largest of all the industries. The Rubber and Petroleum industry (SIC 29) also has a statistically significant

[27] This finding is consistent with the recent case study by Ransom and Pope (1995). They study daily Utah hospital admissions from 1985-1991 for breathing problems caused by small particulate matter caused by the local steel mill. They have a "natural experiment" because this steel mill is the only major producer of particulates in the area and because for one year the mill shut down due to a labor dispute. When the steel mill was open, the area averaged 12.6 violations of the 24 hour particulate standard while when the mill was closed the particulate standard was never violated.

impact on particulates. In 1982, an extra standard deviation of this industrial activity raises a county's particulate level by .71. SIC 30, 32, and 34 have a positive but statistically insignificant impact on particulates. Perhaps reflecting the multicollinearity problem, "all other manufacturing" has the wrong sign but is statistically insignificant. This specification highlights that different manufacturing industries have different pollution levels. In results that are available on request, I have further disaggregated SIC 33 into four digit industries such as SIC 3312 (steel mills) and have found that a county's activity in SIC 3312 has a larger impact on particulates than other SIC 33 industries.[28]

The next several specifications presented in Table Four study the robustness of the pollution externality caused by the primary metals industry. Specification (2) is identical to specification (1) except I now run a median regression which is robust to outliers. Interestingly, the coefficient on primary metals grows from 1.85 to 2.02. In specification (3), I estimate a log-linear specification and find that an extra standard deviation of SIC 33 raises particulates by 2.5%, while an extra standard deviation of SIC 29 (Rubber and Petroleum) increases particulates by 1.7% and an extra standard deviation of SIC 32 (Stone, Clay, Glass) increases particulates by 1.5%.

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[28]Steel mills represent roughly 80% of employment in SIC 33 (primary metals).

Estimating the pollution production function at several points in time allows a test of whether economic activity's impact on pollution is falling. Specifications (4-6) of Table Four test this hypothesis by estimating the same pollution production function but now using the 1987 cross-section. A test of manufacturing capital's vintage effects and regulatory success is to study whether $ (pollution per unit of economic activity) is falling over time.[29] Specification (4) shows that pollution per unit of economic activity has fallen for SIC 29, 30, 32, and 33. For the primary metals industry the coefficient fell from 1.85 to 1.29. This decline could be generated by a composition effect that the oldest dirtiest plants have died and that new plants are build under a more stringent regulatory standard (Portney 1990).[30]

It is important to quantify manufacturing's externality in the Rust Belt because of this region's high population density and because its capital stock is older. Given the findings in Table Four and the apparent multicollinearity problems, I

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[29]While I only have two cross-sections of ambient pollution data in 1982 and 1987, ideally researchers would want to take a longer time-series and decompose improvements in local air quality by whether they are generated by declines in the density of polluting activity or because pollution per unit of economic activity is falling.

[30]I have also used my county particulate data from 1982 and 1987 to form a panel to estimate first differenced specifications. I simplified the specification to the growth rate of particulates from 1982 to 1987 on the growth rate of SIC 33 activity and the growth rate of all other manufacturing activity. There were 522 observations in the regression because 388 counties have zero SIC 33 activity in this period. Interestingly similar to the levels regression, I find a statistically significant and positive elasticity of .02 for primary metals.

simplify the specification in Table Five and only include as independent variables, a county's density of primary metals output and the county's employment density and employment density squared. Employment density could proxy for many variables such as transport activity and electric power creation. Specification (7) presents the estimates for the full sample based on the 1982 data. I find that primary metals continues to have a significant impact on particulates. Interestingly, I have found that employment density is statistically insignificant if entered as a linear term but is highly statistically significant as a quadratic. The estimates in Specification (7) indicate that an extra 100,000 jobs in a county which had 500,000 jobs and a square area of 1000 would increase particulate pollution by 1.02 units. In specifications (8-9), I split the 1982 national sample into those counties in and outside of the Rust Belt. Specification (8) presents the Rust Belt results and specification (9) presents the non-rust belt results. The key finding is that primary metals activity has a much larger and statistically significant impact on particulates in Rust Belt counties. Since newer plants fall under the Clean Air Act's more stringent New Source Performance Standards, this is evidence of the consequences of older plants facing more lax regulation (Portney 1981, Crandall 1983). This suggests that there is a larger air quality gain when older plants decline relative to the newer capital vintages located outside the Rust Belt. This finding is also evidence that newer minimills located outside of the Rust Belt are polluting less than integrated steel plants (Barnett and Crandall 1986). In addition to stratifying the data by whether a county is located in the Rust Belt, I have also stratified the data by whether a county was assigned to non-attainment status in 1977. In results that are available on request, I find that pollution per unit of primary metals activity is lower in non-attainment than attainment counties (the ratio is roughly two to one). While non-attainment counties contain more primary metals activity than attainment counties, plants in the non-attainment counties pollute less. This is suggestive evidence that regulation has played a role in reducing pollution per unit of primary metals activity. Specifications (10-12) repeat the estimation using the 1987 sample. The results are consistent with they hypothesis that pollution per unit of economic activity decline from 1982 to 1987 for the primary metals industry.

Table Six presents more estimates of equation (1) where I have augmented the basic specification to include county level variables. My goal is to study the robustness of the primary metals' impact and to test certain theories of the production of pollution. Specification (13) fits the 1982 level of particulates as a function of manufacturing and adds to the specification, a county’s real per-capita income in 1980 and its square, manufacturing’s share of county employment, average manufacturing plant size as measured by average number of workers, and the share of the county that voted for the Democrat candidate for President in 1980. Primary metal’s coefficient is statistically significant and positive as is the coefficient on total county activity in SIC 29, 30, 32, and 34. Several of the new variables are statistically significant. Increasing the share of a county’s Democrats has a statistically significant effect on lowering particulate levels. One interpretation is that this variable proxies for a demand for environmental protection. Similar to Grossman and Krueger’s (1995) cross-national findings on the relationship between per-capita income and environmental quality, I find that at first increases in county income increase local pollution levels but at a turning point of $13,000 (1982 $) air pollution begins to decline with further increases in income. Increases in county average firm size raise pollution levels. Increasing a county’s average firm size by one standard deviation (44 workers) raises pollution levels by 1.3 units. Deily and Gray (1991) have found that larger steel plants may have some “muscle” in minimizing regulatory burden especially if they can credibly indicate that they may go bankrupt if regulation is enforced. Since larger plants are more likely to be monitored it is possible that increased plant size, holding all else equal, would have led to less pollution. Counties where manufacturing represents a larger share of the local economy are lower polluting.

My data allows for a test of cross-boundary pollution externalities. Specification (14) repeats specification (13) but drops county level primary metals activity and replaces it with the sum of a county's activity level plus the its neighbors' steel activity. This new primary metals variable proxies for total "area" activity levels. Unfortunately, due to collinearity, I could not include a county's own primary metals activity and its neighbor's as separate regressors. I find that the "total" SIC 33 coefficient is statistically significant and equal to 1.46. This means that an extra standard deviation of total own plus neighbor SIC 33 activity raises a county's particulate levels by 1.75. This is larger than the estimate reported in specification (13) that showed that for a given county a standard deviation of SIC 33 activity raises that county's particulates by 1.53. This suggests that cross-boundary externalities for particulates do exist.

An important robustness check on my results is to include state fixed effects. Although they are suppressed, Specification (15) controls for them. Interestingly, the Rust Belt states do not have large positive or negative fixed effects. States such as Colorado, Nevada, Texas and Idaho have large positive particulate fixed effects. The coefficient on SIC 33 is robust to state fixed effects but the coefficients on SIC 29, 30, 32, 34 are not. Interestingly, the coefficients on share of county that are Democrat, share of county employment in manufacturing and average county firm size all flip signs.

The final specification in Table Six switches from particulates to sulfur dioxide as the dependent variable. I include this partially as a robustnest check because it is well known that coal fired electric power plants (located mostly in Ohio) are the major contributor to ambient sulfur dioxide. Specification (16) indicates that primary metals plants do not have a positive impact on this pollutant but that state coal consumption is positive and significant at the 1% level.[31]

In Tables Four-Six, I have focused solely on manufacturing's impact on ambient air quality. The primary metals industry has a robust impact on air pollution across the specifications. Clearly, there are other environmental margins which are affected by manufacturing. To document this, I present additional evidence based on the Toxic Release Inventory data. The primary metals industry is the largest producer of land waste. TRI data

[31]To further study the relationship between ambient sulfur dioxide and state coal consumption, I regressed sulfur dioxide at the state/year level on state/year coal consumption by electric utilities. I find strong evidence of a temporal decline in sulfur dioxide per unit of coal consumption. In 1980, 35% of the nation's electric utility coal consumption was centralized in five Rust Belt states: West Virginia, Illinois, Indiana, Pennsylvania, and Ohio. Thus, for sulfur dioxide the Rust Belt has experienced improvements because coal intensive plants have sharply reduced their pollution per unit of economic activity.

indicate that the primary metals industry is the second largest producer of production related waste (SIC 28 Chemicals is the largest).[32] If this waste is not exported out of state, then this production leads to increased exposure for those who live near the plant.

My contribution using the TRI data is to explain cross-sectional variation in toxic releases by county/industries. The EPA (1996) has calculated national estimates of emissions per dollar of output by two digit industry but has made no attempt to spatially disaggregate this data to explain cross-county variation in pollution per unit of economic activity. I estimate a version of equation (1) to explore how pollution per unit of output varies with respect to county demographic variables, politics, the industry in question and state fixed effects. Such estimates are useful for judging the pollution reductions possible from reduced manufacturing activity.

Using the TRI micro data, I aggregate up for each two digit industry in each county in 1988 its total toxic releases. I use the LRD to aggregate up for each two digit industry in each county in 1987, the county/industry's total value shipped. Thus, for each county/industry I have an indicator of total toxic releases and total output. Forming a ratio of the two yields a county/industry's pollution per dollar of output. For example,

[32]In 1994, SIC 33 produced 22.33 million pounds of production related waste per billion dollars of value of production (EPA 1996 Table 2-27).

total pounds of toxic releases per dollar of output by SIC 33 in Allegheny county in 1988 is one of the observations, I try to explain. A high value of ratio indicates a pollution intensive sector. Table Seven reports my findings for explaining cross-sectional variation in county/industry toxic releases per unit of dollar output. I include as independent variables: a county’s share of democrats, income, college graduate share, size of firms, population density, and manufacturing ratio. Since this is industry level data, I include industry fixed effects as well as state fixed effects. To simplify the presentation, SIC 33 is the omitted category. Since most of the industry dummies are negative, this is additional evidence that there is a “silver lining” of the decline of SIC 33. Only SIC 25 (Furniture and Fixtures), 26 (paper) and 28 (Chemicals), 31 (Leather), 37 (transportation equipment) pollute more per unit of output. Studying the suppressed state fixed effects, I find Interesting that I no evidence that pollution per unit of activity is higher in Rust Belt than outside the Rust Belt. In fact, New Jersey has one of the lowest state fixed effects and the highest state fixed effects tend to be in less populated areas. I have correlated the state fixed effects from the particulate fixed effect regression, specification (15), with the TRI state fixed effects and found no evidence of a positive correlation. Additional interesting findings reported in Table Seven are that pollution levels per unit of output are lower where more of a county's population vote Democrat or are more educated. In addition, I find weak evidence that richer counties are exposed to less pollution per unit of output. I find stronger evidence that more densely populated counties feature less pollution. The education, Democrat, income and density findings all consistent with the Coasian concept that polluting activity will migrate to where its social costs are lowest. Finally, I find that larger average plants sizes are associated with more toxic releases per unit of output. This may be evidence that such plants have some influence on avoiding being regulated.

Which Cities have the Biggest Externality?

Pollution production function estimates for ambient particulates and toxic releases have clearly shown the importance of SIC 33 as being a high polluter per unit of activity. Table One showed that SIC 33 is a large industry that has been mainly concentrated in the Rust Belt. This industry has declined sharply especially between 1977 and 1982. Pennsylvania experienced the destruction of 71% of these jobs between 1967 and 1987.[33] The primary metals industry is highly centralized in the Rust Belt. In 1967, 6.9% of the nation's manufacturing

[33] Davis, Haltiwanger and Schuh (1996) present additional documentation of the decline of the steel industry from the 1970s-1980s (p112).

jobs (1,281,000) were in SIC 33 industry. 67.4% of these jobs were in New York, New Jersey, Pennsylvania, Ohio, Indiana, Illinois, Michigan and Wisconsin. It is intuitive that those cities whose employment was concentrated in primary metals will experience the largest pollution reductions.

In this section, I quantify for cities whose employment was concentrated in SIC 33 how large an impact did the decline of SIC 33 have on such cities' pollution levels. In the absence of reliable pre-1980 data, it is an interesting interpolation exercise and it presents evidence on the size of the "silver lining" of this most polluting sector. To quantify the "silver lining" for Gary and Pittsburgh, I use equation (3) which related changes in employment to changes in pollution. To implement equation (3), I need estimates of the relationship between manufacturing activity and pollution levels. I use the estimates from Table Five, specification #7 and #10 and combine these with the results in Table Eight that present estimates of each two digit SIC industry's real average value product by year.[34] For almost all the industries, the average value product of labor has increased from 1972 to 1987. For primary metals there is a 30% increase from 1972 to 1987. This is evidence that I could not

[34] I created this table by sorting the data by year and by two digit industry and for each year/industry summing up total value shipped and total employment only for Rust Belt plants. Dividing total value shipped by industry by year by total employment yields each industry's average product by year. I use the Bartelsman and Gray (1996) production price deflator to translate the dollar value into 1987 dollars.

have simply regressed 1982 pollution on 1982 SIC 33 employment levels and interpolated back in time based on earlier SIC 33 employment levels. This approach would have overestimated previous pollution levels caused by primary metals activity because a unit of labor in 1982 produces more output than in the past.

Table Nine presents the counter-factual of how much higher was a county's air pollution in the past because of higher past levels of SIC 33 activity. In Table Nine, I present the index for Gary, Pittsburgh and Los Angeles. I include the latter city as an example of an important non-Rust Belt city that was experiencing manufacturing growth during this time interval. The index's units are micrograms per cubic meter. I predict that the decline of SIC 33 in Gary, Indiana has led to a 18 unit increase in air quality from 1972 to 1987 and for Pittsburgh an increase of 13.[35] Unlike these Rust Belt cities, Los Angeles's manufacturing growth is predicted to not have degraded local air quality.[36] It is important to note that these interpolations are based on the assumption that the estimate the 1982 estimates of pollution per

[35]Gary, Indiana is defined as Lake County and Pittsburgh is Allegheny county. Youngstown, Ohio (Mahoning county) is another area that has experienced a sharp steel decline (Crandall 1993). The ambient particulate data indicate this county's particulates fell from 80 units to 53 from 1981 to 1986. Based on the actual particulate data, Gary's air pollution fell from 89.4 to 70.4 from 1981 to 1986 and Pittsburgh's air pollution levels fell from 69.8 to 50.1.

[36]It is important to note that my county economic activity measures are densities, i.e. they are scaled by county area and Los Angeles is a very large county.

unit of activity held in 1972 and 1977. Since the pollution per unit of economic activity fell from 1982 to 1987, it is likely that my index is a lower bound on the pollution decline. This is especially likely if environmental regulation has lowered pollution per unit of economic activity in the 1970s.

What is the dollar value of the reduced pollution externality? I use estimates from Portney (1981) and Smith and Hwang (1995). Portney reports EPA estimates of the mortality risk from particulate exposure. I use these estimates and calculate an individual's willingness to pay for reduced particulates. To simplify the calculations, I assume that people are risk neutral and that their willingness to pay for reduced particulates is independent of the current level of particulates.[37] Table Ten reports willingness to pay for reduced particulate levels under different assumptions on one's value of life and the mortality impact of particulates. Taking the mortality rate of an increase in particulates as given, I estimate how much a risk neutral individual would be willing to pay under different scenarios on his value of life (Viscusi

[37]Portney takes an EPA's mortality study's estimate that a 18 microgram per cubic meter reduction in particulates will lower the annual risk of death for a middle aged man by .00009. This implicitly is assuming that mortality is a linear function of particulate exposure.

1993).[38] Table Ten indicates that an individual, age 45-64, who values his life at $5 million dollars would be willing to pay $2000 for a 10 unit decrease in particulates. Interestingly, this $200 per unit payment is just double the mean estimate Smith and Hwang's (1995) meta-analysis of hedonic home price regression capitalization of local particulate levels. Evaluating over 80 city level hedonic studies which estimated the implicit capitalization of particulates into home prices, Smith and Hwang's (1995) meta-analysis reports a mean home price capitalization of $100 per particulate unit and a median of $22.[39] These valuation approaches estimates suggest that Pittsburgh's thirteen unit improvement translates into a one time dollar gain of $1300-$2,500 gain for a family who moves there. This is likely to be a lower bound because I am assuming that the marginal utility of reduced particulates is a linear function when instead the willingness to pay would be higher in locations with higher pollution levels. These estimates are also conservative because I have only estimate the impact on two environmental margins. Further research could incorporate ozone

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[38]Multiplying the value of life times the probability of death yields the upper bound of what a risk neutral fully informed agent would be willing to pay to avoid exposure.

[39]In their cross-city study, Blomquist, Berger and Hoehn (1988) report a yearly full price of $.36 per unit of particulates. Thus, an individual would pay $3.6 a year for a 10 unit reduction. Assuming a 5% interest rate this would equal a one time payment of $72. This cross-city estimate is significantly lower than hedonic estimates from within city estimates (Smith and Hwang 1995).

smog declines attributable to steel activity declines. In addition, I have assumed that the environmental benefits of reduced activity only affect the county. Incorporating cross-county spillovers would lead to a larger benefits estimate. It is important to note that air quality is a local public good, thus reductions in pollution in populated areas will have larger total health benefits than if a polluting plant had closed in a less populated area.

Since the TRI is emissions, not ambient data, I cannot map it into ambient concentrations to yield a willingness to pay per ton of emissions. For example, in constructing the dependent variable in the TRI regressions, I add tons of air releases, water, and land and across chemicals released to form total pounds of all toxic releases. Linking TRI releases to hedonic valuation would be possible if there were estimates of how TRI releases that are not shipped out of state increase the likelihood of a new Superfund site being announced. If one could link the "production" of Superfund sites to the quantity of county/industry TRI emissions, then one could use recent estimates of the impact of proximity to Superfund sites on home prices as a valuation measure (see Kolhase 1991, Kiel and McClain 1995).

IV. Pollution Externalities and Urban Compensating Differentials

The decline of primary metals leads to improved air quality but city quality of life might still fall if increased local unemployment lead to a lower tax base and lower level of services provided. Land owners bear the incidence of shocks to local amenities such as identification of new Superfund sites or improved efficiency in the provision of local public education. Reduced demand for Rust Belt steel should lower land prices in Pittsburgh and Gary because the value of proximity to the production centers falls by more than the value of increased environmental levels.[40] If air quality is a normal good, then unemployed manufacturing workers who were home owners are likely to sell out and move to another city as their employment prospects have fallen. It is possible that service workers and service firms will be attracted to Rust Belt cities that now offer lower rents and higher amenity levels than before the decline of heavy manufacturing.

The regional adjustment literature has stressed migration’s role in helping local labor market demand adjust to shocks (DaVanzo 1978, Blanchard and Katz 1991, Bartik 1991). If local amenities and local industrial output are linked, then declining cities may experience an offsetting improvement in quality of life that may accelerate a city’s adjustment to a negative

[40] Otherwise, the Coase theorem would say that the plant should not have existed.

sectoral demand shock.[41] As Rust Belt cities offer improved environmental quality but less economic opportunity for low skilled workers, there may be an out migration of manufacturing workers and immigration of high skilled service workers. Clearly the extent of this reallocation depends on whether “footloose workers” care about environmental amenities and whether their earnings are independent of output in the declining sector.

VI. Conclusion

Based on a spatial merger of county level ambient air quality data to micro manufacturing data, this paper presented new estimates of manufacturing’s pollution externality. I found that Rust Belt counties, that had a high concentration of primary metals activity, experienced significant improvements in environmental quality as measured by particulates and toxic releases. This paper’s estimates of the environmental “silver lining” of declining manufacturing activity can be used as an input in a full cost/benefit analysis of regional sectoral change from manufacturing to services.

My calculations are suggestive that for heavily undiversified cities such as Gary and Pittsburgh, the total value of the environmental externality, including water

[41] The key counter-factual is to ask how quickly would a city “rebound” if the declining sector did not cause an increase in local amenities?

degradation and toxic releases, is substantial. As indicated in Table Four, the externality estimates for other industries are relatively low. Only cities such as Gary, Indiana or Pittsburgh with huge concentrations of employment in the polluting sector are likely to experience a significant improvement. In 1972, the Rust Belt did have a heavy share of SIC 23 (Apparel), 35 (Industry Machinery), 36 (Electronics). For the Rust Belt as a whole these industries declined by roughly 300,000 jobs, 220,000 jobs, and 240,000 jobs respectively between 1972 and 1987 but I find no evidence of a “silver lining” for cities with employment concentrated in these industries.

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Table One

Employment Trends in SIC 33 (Primary Metals)

State	1967	1972	1977	1982	1987	1967 to 1987 % change
Nation	1281	1143	1114	854.1	701.1	-45.3
Illinois	108.6	98	89	60.7	43.2	-60.2
Indiana	111	103	102	86.2	60.3	-45.7
New Jersey	37.6	31	21	21.6	18.3	-51.3
New York	72.9	58	53	38.2	22	-69.8
Ohio	169.6	142	134.2	97.6	65.6	-61.4
Pennsylvania	233.1	186	172	118.7	67.3	-71.1
Six State's share of national employment in SIC 33	57.2%	54.1%	51.2%	49.4%	39.5%	
Employment Expressed in 1000s. Data Source: LRD and Printed Records of the Census of Manufacturers Geographic Area Series						

Table Two

Manufacturing and Services Employment Shares

Variable	Nation	Non-Rust Belt	Rust Belt	Los Angeles	Pittsburgh
1970 manufacturing share	21.9	18.8	27.3	24.7	24.7
1980 manufacturing share	18.5	16.8	22.1	21.9	20.0
1989 manufacturing share	14.7	13.8	16.6	17.7	10.6
1970 service share	18.5	18.6	18.3	22.4	23.2
1980 service share	21.7	21.3	22.6	26.5	27.1
1989 service share	27.0	26.5	28.2	32.2	36.8

1970-1989 % change in manufacturing employment	1.4	22.1	-23.6	11.7	-53.4
manufacturing and service shares are share of total employment in a county in a given year. The data source is the BEA's REIS cd-rom.					

Table Three

County Level Summary Statistics

County Level Variables	mean	standard deviation
mean particulates in 1982	50.108	15.41
total value shipped per square mile of SIC 29 (Rubber and Petroleum)	.20	1.34
total value shipped per square mile SIC 30 (Rubber and Plastics)	.10	.30
total value shipped per square mile SIC 32 (Stone, clay and glass)	.072	.20
total value shipped per square mile SIC 33 (Primary Metals)	.19	.74
total value shipped per square mile SIC 34 (Fabricated Metals)	.24	.83
total of county total value shipped per square mile	4.84	40.69
1982 income (1,000s)	10.21	2.14
share of democrat vote for president	.399	.10
total value shipped per square mile Total of SIC 29,30,32 34	.61	2.05
Externality Variable: total value shipped per square mile Local SIC 33 + adjacent county SIC 33	.39	1.21
Manufacturing's share of total employment in 1982	.172	.108
Average firm size	60.19	44.13
mean sulfur dioxide in 1982	19.01	13.36
electric utility coal consumption by state (1000s tons)	369.26	336
TRI Total Releases in 1988	70.12	2317
county is the unit of analysis. All manufacturing data reported here are from 1982. The 1987 manufacturing summary statistics are available on request. Manufacturing's units are millions of 1987 dollars total value shipped per square mile of county land area (total millions of 1987 dollars value shipped per county square mile). TRI releases are pounds of all releases per $1,000 of a county/industry's total value shipped.		

Table Four

OLS Pollution Regressions Based on 1982 and 1987 Data

$$Pollution_{jt} = \sum_h B_{ht} * SIC(h)_{jt} + \epsilon_{jt}$$

specificiation	(1)	(2)	(3)	(4)	(5)	(6)
	1982 data			1987 data		
dependent variable	TSP	TSP	log(TSP)	TSP	TSP	log(TSP)
independent variables	OLS National Sample	Median National Sample	OLS National Sample	OLS National Sample	Median National Sample	OLS National Sample
SIC 29 Rubber and Petroleum	.71** (.22)	.61* (.26)	.013** (.0042)	.020 (.29)	-.12 (.25)	.0009 (.005)
SIC 30 (Rubber and Plastics)	1.44 (1.73)	1.85 (1.97)	.032 (.033)	.16 (1.67)	-.29 (1.58)	.016 (.029)
SIC 32 (Stone, Clay, glass)	3.59~ (1.91)	.64 (1.56)	.079* (.037)	2.39 (1.52)	3.10** (1.00)	.052* (.026)
SIC 33 (Primary Metals)	1.85** (.34)	2.02** (.32)	.034** (.007)	1.29** (.39)	2.06** (.32)	.024** (.007)
SIC 34 (Fabricated Metals)	.32 (.50)	.99 (.65)	.010 (.01)	.55 (.53)	.83 (.58)	.011 (.009)
all other manufacturing except SIC 29,30,32,33,34	-.018 (.013)	-.011* (.005)	-.00034 (.00025)	-.003 (.015)	-.005 (.004)	-.00007 (.00027)
constant	50.42** (.49)	48.06** (.53)	3.89 (.0094)	54.00** (.63)	50.16** (.63)	3.94** (.01)
R2/obs	.09 1072	.09	.09	.03 903	.07	.05

Note: standard errors in (). Each column of this table reports a separate regression where the dependent variable is a county's mean pollution reading in 1982. This air quality measure is regressed on county manufacturing activity in a given two digit SIC industry. This table reports the coefficient from the particulate regression and its statistical significance; ** indicates 1% level, and * indicates 5% level.

Table Five

OLS Pollution Regressions

$$Pollution_{jt} = \mathrm{B}_t * SIC(33)_{jt} + \Gamma_t * Emp_{jt} + \psi_t * Emp_{jt}^2 + \epsilon_{jt}$$

specification	(7)	(8)	(9)	(10)	(11)	(12)
	1982			1987		
dependent variable	TSP	TSP	TSP	TSP	TSP	TSP
independent variables	OLS National Sample	OLS Rust Belt Sample	OLS Non-Rust Belt Sample	OLS National Sample	OLS Rust Belt Sample	OLS Non-Rust Belt Sample
SIC 33 (Primary Metals)	2.31** (.31)	2.41** (.27)	1.40 (1.17)	1.54** (.36)	1.82** (.30)	.35 (1.50)
employment	11.26** (4.19)	15.59** (5.90)	44.59** (14.76)	11.06** (4.49)	17.51** (6.17)	33.58* (15.59)
employment squared	-1.04** (.39)	-1.42** (.53)	-40.42** (14.97)	-.91* (.40)	-1.42** (.52)	-24.06~ (14.6)
constant	50.87** (.47)	49.62** (.72)	50.78** (.62)	53.63** (.57)	50.13** (.85)	54.06** (.75)
observations	1072	284	788	903	226	656
R2	.07	.27	.03	.03	.20	.01

Note: standard errors in (). Each column of this table reports a separate regression where the dependent variable is a county's mean pollution reading in 1982. This table reports the coefficient from the particulate regression and its statistical significance; ** indicates 1% level, and * indicates 5% level. Specification (12) excludes all data points from texas.Employment is measured in 10,000 jobs per square mile; its mean is .033 and its sd is .35

Table Six

1982 OLS Pollution Regressions Augmented Specifications

$$Pollution_{jt} = \sum_h B_{ht} * SIC(h)_{jt} + \psi * X_{jt} + \epsilon_{jt}$$

specification	(13)	(14)	(15)	(16)
pollutant	TSP	TSP	TSP	SO2
independent variables	OLS	OLS	OLS state fixed effects supressed	OLS
all other manufacturing	-.004 (.011)	-.0122 (.012)	.009 (.0098)	-.14 (.10)
the sum of activity in SIC 29,30,32,34	.79** (.16)	.79** (.17)	.22 (.15)	.42 (.33)
SIC 33	2.07** (.34)		1.80** (.30)	-.93 (.71)
SIC 33 for county and adjacent counties (total externality)		1.46** (.27)		
Share of County that vote Democrat 1980	-14.17** (4.87)	-14.00** (4.89)	12.93* (5.34)	-.63 (10.80)
per-capita county income	2.25~ (1.33)	2.25~ (1.33)	4.35** (1.24)	-4.08 (3.31)
square of per-capita county income	-.086~ (.055)	-.085~ (.056)	-.16** (.052)	.21 (.13)
manufacturing's share	-23.63** (6.03)	-24.54** (6.05)	6.80 (6.17)	43.4 (12.81)
Average firm size	.032* (.014)	.037** (.014)	-.002 (.013)	.05 .041)
coal				.0137** (.0021)
constant	44.27** (8.32)	43.97** (8.31)		22.72 (21.67)
R2	.12	.11	.45	.26
observations	1070			272

Note: standard errors in (). Each column of this table reports a separate regression where the dependent variable is a county's mean pollution reading in 1982.. This table reports the coefficient from the regression and its statistical significance. ** indicates 1% level, and * indicates 5% level. Share of democrat is the share of acounty voting for democrat in 1980 presidential race. Income is county per-capita income in 1982, manufacturing's share is a county share of employment in 1982 in manufacturing, competition is county total employment in manufacturing divided by the number of plants in the county. Coal is state consumption of coal by electric utilities.

Table Seven

1988 County Toxic Release Inventory Regression

$$\log(Y_{jht}) = \sum_h \Phi_{ht} * D(h)_{jt} + \psi * X_{jt} + U_{jht}$$

$$Y_{jht} = (TRI\ Emissions_{jht} / Total\ Value\ Shipped_{jht})$$

The unit of analysis is industry h in county j at time t. The independent variable D(h) is a dummy variable for industry. State fixed effects are included.

independent variables	Beta	standard error
21 Tobacco	-.03	.98
22 (Textile Mill)	-.73**	.20
23 (Apparel and Other Textiles)	-1.14**	.40
24 (Lumber and Wood)	-1.35**	.16
25 (Furniture and Fixtures)	.84**	.18
26 (Paper)	.10	.16
27 (Printing and Publishing)	-.65**	.19
28 (Chemicals)	.31*	.13
29 Rubber and Petroleum	-1.17**	.21
30 (Rubber and Plastics)	.22~	.13
31 (Leather)	.42	.27
32 (Stone, Clay, glass)	-1.01**	.15
34 (Fabricated Metals)	-.30*	.13
35 (Industrial Machinery)	-1.02**	.14
36 (Electronics)	-.25~	.14
37 (Transportation Equipment)	.16	.14
38 (Instruments)	-.80**	.20
39 Misc	.60**	.19
Share of Democrat 1980	-.88*	.41
per-capita income	-.84	.63
square of per-capita income	.0000135	.000012
county college graduates as a share of county population in 1980	-7.08**	1.59
Average manufacturing firm size	.0021*	.001
population density (people per square mile of county land area)	-.000046**	.000012
manufacturing ratio	-.96*	.44

Each column of this table reports a separate regression where the dependent variable is a county/industry's total TRI releases scaled by county/industry total value shipped. This has the interpretation of pollution per unit of output. Omitted industry is SIC 33 primary metals; the mean and standard deviation for percentage ba is .08 and .034 and for density is 637 and 2627. Observations equals 7048 and the R2 is .10

Table Eight

Rust Belt Average Value Product by Industry by Year

SIC name and number	1972	1977	1982	1987
20 Food products	157.2271	186.8628	207.5931	234.9781
21 Tobacco	110.5954	141.0508	165.3193	263.7126
22 (Textile Mill)	59.00282	63.62746	64.96477	78.56157
23 (Apparel and Other Textiles)	44.5443	50.61849	60.07906	74.12732
24 (Lumber and Wood)	72.11079	67.8007	70.68777	85.84425
25 (Furniture and Fixtures)	62.38874	66.9283	74.38477	86.56307
26 (Paper)	103.7367	119.9257	126.0971	144.9128
27 (Printing and Publishing)	87.46735	93.17104	92.52355	102.8598
28 (Chemicals)	172.0116	196.6546	193.8087	267.7779
29 Rubber and Petroleum	688.2892	856.1199	764.2761	926.4109
30 (Rubber and Plastics)	76.49721	77.4915	81.15758	99.84039
31 (Leather)	48.33584	52.80254	55.7416	70.07589
32 (Stone, Clay, glass)	90.21223	94.11768	90.9028	116.2552
33 (Primary Metals)	134.3867	142.5385	127.5151	174.1382
34 (Fabricated Metals)	90.40461	95.73618	89.36993	106.7395
35 (Industrial Machinery)	32.83267	61.81825	73.50094	109.4954
36 (Electronics)	63.62366	77.21139	87.20531	106.284
37 (Transportation Equipment)	168.0768	195.423	171.6954	235.1835
38 (Instruments)	75.07327	85.3706	95.28526	121.149
39 Misc	69.34592	77.6582	81.00214	94.95663

For Rust Belt states, I calculate total value shipped for each industry in each year and divide this by total employment for each industry in each year. This yields average product by industry by year. The total value shipped data is measured in $1,000s of 1987 dollars using the Bartelsman and Gray (1996) price deflator for value of shipments. This table is based on equation (2) in the text.

Table Nine

Predicted County Impact of Declining Primary Metals Activity

	Los Angeles County	Gary, IN Lake County	Pittsburgh, PA Allegheny County
Year	imputed particulate level	imputed particulate level	imputed particulate level
1972	54.1	87.1	68.4
1977	54.1	88.1	68.8
1982	53.7	77.9	61.1
1987	53.6	65.6	55.4

For each county in each year, the index shows what a county's particulate level would be if primary metals had remained at earlier levels of activity (i.e if there was no job destruction in the primary metals sector), holding total employment at its 1982 level.

$$pollution_{jt} = B_{33,1982} * \phi_{33,t-k} * Emp(33)_{j,t-k} + c$$

The # is from specification (7) in Table Five for years 1972, 1977, and 1982 and is from specification (10) in Table Five for 1987. N(33) is taken from Table Eight. Emp(33) is employment in SIC 33 in county j at time t-k. C is the county's total employment

Table Ten

Willingess To Pay for Reduce Particulate Pollution

thought experiment	value of life	change in mortality rate for demographic group	an individual's Risk Neutral WTP
particulates decline by 10	5,000,000	.0004 (men aged 45-64)	2000
particulates decline by 10	5,000,000	.00005 (men aged 45)	250
particulates decline by 10	1,000,000	.001 men aged 65+	1032
Mortality rates for a given reduction in particulates are taken from Portney (1981). Risk Neutral willingness to pay (WTP) is calculated by multiplying the value of life by the change in the mortality rate.			